the wires, and an error of hundreds per cent. in the case of some of them.

Using the formula (3) which we have arrived at for determining the emissivity of platinum wires of different diameters at 300° C., it follows that to maintain a platinum wire 0·75 mil in diameter at 300° C. would require a current density of 331,000 amperes per square inch, and, if the emissivity of a copper wire of the same diameter and at the same temperature may be taken as being the same, it follows that to maintain a copper wire 0·75 mil in diameter at 300° C. would require a current density of 790,000 amperes per square inch.

II. "On the Time-Relations of the Excursions of the Capillary Electrometer, with a Description of the Method of using it for the Investigation of Electrical Changes of Short Duration." By GEORGE J. BURCH, B.A. Oxon. Communicated by Professor BARTHOLOMEW PRICE, F.R.S. Received September 3, 1891.

(Abstract.)

This paper is in continuation of the author's preliminary note "On a Method of determining the Value of Rapid Variations of a Difference of Potential by means of the Capillary Electrometer," and describes a further simplification of the method then brought forward, consequent on a change in the mode of producing the photographic record of an excursion.

The rapidity of the movement of the meniscus was found to be affected by (1) the degree of concentration of the acid, (2) the length of the capillary beyond the end of the mercury column, (3) the shape of the tube where it tapers to form the capillary, (4) the shape of the orifice. These things might be taken as indicating the action of both mechanical friction and electrical resistance in determining the rate of movement. As was announced in the preliminary note, under ordinary circumstances the instrument is perfectly dead-beat; the meniscus commences to move the instant a difference of potential is communicated to the instrument, and stops directly it is withdrawn. The conditions under which overshooting may occur, and the possible extent of it, are discussed. It was found that, in general, the time-relations of the movement might be expressed by the equation

$$y = ae^{-ct},$$

in which y is the distance of any point upon the curve from its asymptote. The tabular logarithms of a series of ordinates corre

sponding to equal time-intervals are in arithmetical progression, and the sub-tangent to the curve is of constant length. It was also shown in the preliminary note that the tangent to a point on the curve produced by an irregular change of electromotive force coincides in direction with that of the normal curve produced by the difference of potential existing at that instant between the terminals of the electrometer, and on this was based a method of determining the amount of that difference.

Further Investigation of the Formula $y = ae^{-ct}$.

Calibration Error.—The greater the range of the excursion for a given small difference of potential, the slower is the action of the instrument. Hence, in the majority of capillaries, the rate of movement *decreases* as the meniscus approaches the tip of the capillary.

Change of Resistance.—The shorter the length of dilute acid, the smaller is the resistance, and the quicker is the motion; hence, in all instruments there is a tendency to *increased rapidity* as the meniscus approaches the tip of the capillary. The equivalent internal resistance of an electrometer may be written

$$R = r(L+l),$$

where l = the length of the capillary beyond the meniscus at any moment, and L = a constant many times larger than l, and representing the sum total of the mechanical and the remaining electrical resistances. The effect of the change of resistance is so much smaller that it may be completely masked and neutralised by the calibration error, which has an opposite effect.

Change in the Mode of Photographing the Excursions.

In order to bring out the details of the electrical phenomena of muscle, it was necessary to make the plates move faster than was possible with the apparatus hitherto employed. To do this they were attached to a kind of balanced pendulum and caused to describe an arc of a circle. With this arrangement the normal excursion is best expressed in polar coordinates. Time being recorded on a circular arc, t becomes θ. Instead of the rectilinear asymptote there is an asymptotic circle of radius = R. The expression for the radius vector is $r = R \pm y$, the equation connecting y and θ being $y = ae^{-c\theta}$. With such a curve the method of analysis first put forward is no longer applicable. In place of it however there is a still simpler one. The equation to the polar sub-normal, $r \cot \psi = dr/d\theta$, is in this case independent of R, being simply cy. In other words, the polar subnormal to a point on the curve is a constant multiple of its distance

from the asymptotic circle, and consequently, by the same reasoning on which the previous method of analysis was based, represents, on a scale which can be easily determined, and which is constant so long as the resistance in circuit is unchanged, the difference of potential between the terminals of the electrometer, *minus* or *plus* the difference of potential indicated by the *position* of the meniscus above or below the zero-line.

Analysis of a Normal Curve.

Full details are given of the measurement of a normal curve, the equation to which was shown to be $y = ae^{-c\theta}$, the maximum difference between the observed and the calculated values being only 0·071 mm. The constant multiplier in this case was $c = 8{\cdot}50$. Details of five other smaller excursions of known value are also given, showing that the error in determining differences of potential by this method is less than 1 per cent.

Artificial Spikes.

This name was given to excursions produced by two currents in opposite directions, each lasting about 0·005 second. It was intended by this means to investigate the effects of overshooting, and also to ascertain whether the electrometer was capable of discriminating between a current of definite strength suddenly communicated to it, and a more or less gradual rise of a difference of potential extending over a period of equal duration. That it can do so was clearly established. The effect of the elasticity of the meniscus, and of overshooting proper, is shown. With no resistance in circuit it did not exceed 0·01 of the full excursion, and was rendered inappreciable by the introduction of a few thousand ohms.

Part II.

Application of the Method to the Study of the Electrical Variations of Muscle.

After a brief sketch of the problem under consideration and the mode in which the physiological experiments were made, the author describes minutely the manner in which a muscle-curve is analysed. In order to illustrate the kind of information which can be thus obtained, he gives a series of specimen records of the electrical variations of the gastrocnemius of the frog, together with the analysis of each. The interpretation of the results, from a physiological standpoint, he desires to leave entirely in the hands of Professor Burdon Sanderson, to whom he is indebted for permission to make use of the photographs.